Surgical Treatment for Aortic Stenosis Associated with Narrow Annulus

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CITATION:

MINAMI, KAZUAKI ...[et al]. Surgical Treatment for Aortic Stenosis Associated with Narrow Annulus. 日本外科宝函 1981, 50(4): 599-610

ISSUE DATE:

1981-07-01

URL:

http://hdl.handle.net/2433/208544

Arch Jpn Chir 50(4), 599～610, Juli, 1981

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Surgical Treatment for Aortic Stenosis Associated with Narrow Annulus

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Received for Publication, May, 10, 1981.

Introduction

In congenital aortic stenosis due to a narrow annulus, it is difficult to achieve satisfactory results by valvotomy or only prosthetic valve replacement. Because in such cases, valvotomy is of limited value and prosthetic aortic valve replacement is rarely advisable. Some patients, even adults, with aortic stenosis may have a narrow annulus which would pose special technical problems.

In 1974, Konno established a new method for prosthetic heart valve replacement in congenital aortic stenosis associated with hypoplasia of the aortic valve, and the next year he operated upon two patients by his new method: the first was a 3-month-old female who died on the 2nd postoperative day and the other was a 23-year-old woman who survived the operation. In 1975, Rastan established a method similar to Konno's and reported 21 clinical cases.

We operated upon two patients with congential aortic stenosis associated narrow annulus by this surgical procedure. Two case reports and the related problems in this technique will be described herein.

Key words: Aortic stenosis, Konno's operation, Complications. Ultrasonic cardiotomogram, IABP.
索引語：大動脈狭窄症，今野の手術，合併症，超音波断層像，大動脈内バルーンパンピング
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Case reports

Case 1.

The patient, a 13-year-old boy, was born as one of a twin following an uneventful full-term pregnancy and normal delivery. Body weight at birth was 1990 gm. Growth was smooth and no retardation was found. A cardiac murmur was detected at the age of 5 years and he was referred to the Department of Pediatrics, Kyoto University Hospital. Until then he had been a out-patient, diagnosed as a venticular septal defect (VSD) associated aortic regurgitation (AR). There had been no cyanosis, breathholding attack or syncope attack. At the age of 12 years, upon physical examination, cardiac enlargement and cardiac hypertrophy were detected on the chest roentgenogram and the electrocardiogram, respectively. Palpitation on exertion, dyspnea, oppressive chest pain and edema were not found in the past.

On November 18, 1976, he underwent a preoperative cardiac catheterization study. The pressures (mmHg) in the cardiac chambers and great vessels are shown in Table I. The catheter could be passed into the left ventricle through the aortic valve across which the pressure gradient was 98 mmHg. Angiocardiography showed a mild aortic regurgitation and a moderate narrow aortic annulus (Fig. 1). Upon auscultation, there was a Grade 3/6 to-and-fro murmur heard loudest in the 3rd intercostal space over the sternum. Thrill was strongly palpable in the suprasternal region. The liver and spleen were not palpable. An electrocardiogram showed a regular sinus rhythm, with a mean electrical axis 50 degrees, and definite left ventricular hypertrophy. T-wave inversion was seen between V3 and V6, and S of V1+R of V5 was 9.1 mV (Fig. 2). The chest roentgenogram showed a mild cardiomegaly with a cardiothoracic ratio of 0.51. Pulmonary vascular markings were not increased (Fig. 3). Echocardiogram showed remarkable hypertrophy of left ventricular posterior wall and interventricular septum.

On April 11, 1977, an operation was performed based on the diagnosis of aortic stenosis and regurgitation, using a heart-lung (H-L) bypass and coronary perfusion. The diameters of the

Table I. Preoperative and postoperative cardiac catheterization data

	Case 1 T.Y. 13y m		Case 2 K.K. 12y f	
	Pre-op	Post-op	Pre-op	Post-op
m-PA	31/15(21)	30/20(25)	22/12(17)	40/20(30)
RV_o		45/5, 15	32/0, 5	60/2, 20
RVi	38/2, 10	48/8, 8	32/0, 5	60/2, 20
RAm	(6)	(3)	(3)	(17)
Ao(asc)	100/70	100/60(80)	85/65(75)	124/88
LV	198/0, 18		240/0, 14	
Shunt				L→R 41.5%
CI	2.98		3.07	2.92

Legend: m-PA, main pulmonary artery. RV_o, outflow tract of the right ventricle. RVi, inflow tract of the right ventricle. RAm, middle portion of the right atrium. Ao(asc), ascending aorta. LV, left ventricle. CI, cardiac index. ( ): mean pressure.

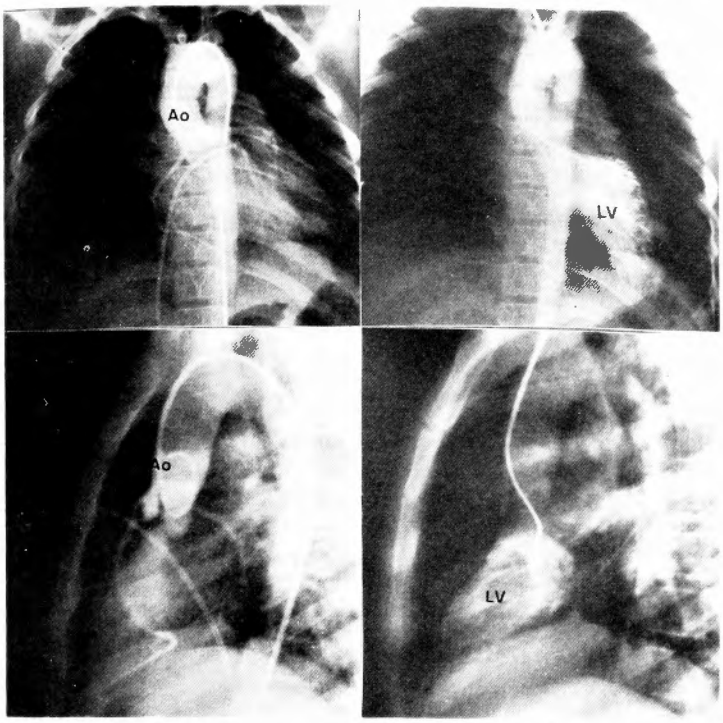

Fig. 1. Preoperative angiocardiogram in Case 1 shows a valvular aortic stenosis with mild aortic narrow annulus and a mild aortic regurgitation. There is no subaortic stenosis.

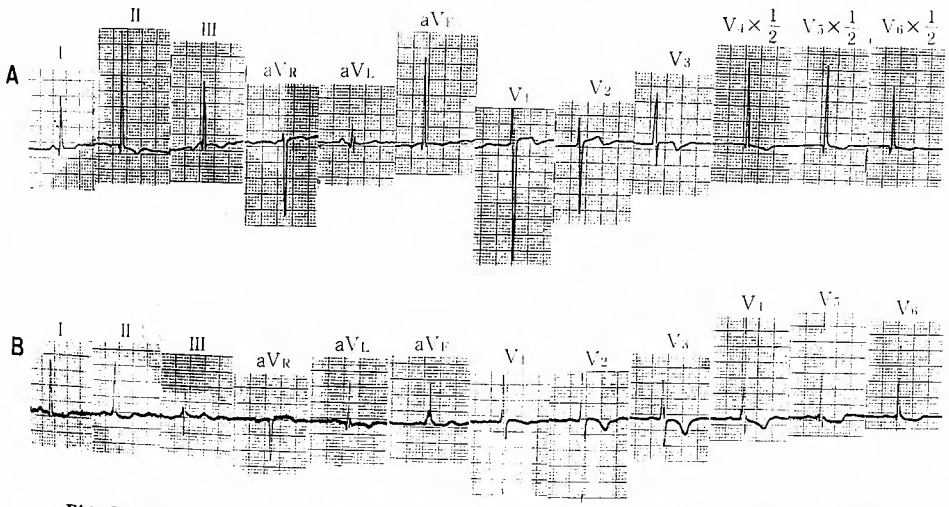

Fig. 2. A. Preoperative electrocardiogram in Case 1 shows a regular sinus rhythm, with a mean electrical axis 50 degrees, and definite left ventricular hypertrophy. T-wave inversion is seen between V3 and V6, and S of V1+R of V5 is 9.1 mV. B. Postoperative electrocardiogram taken 4 years postoperatively shows a marked improvement. S of V1+R of V5 decreases to 5.7 mV. Complete right bundle branch block is not present.

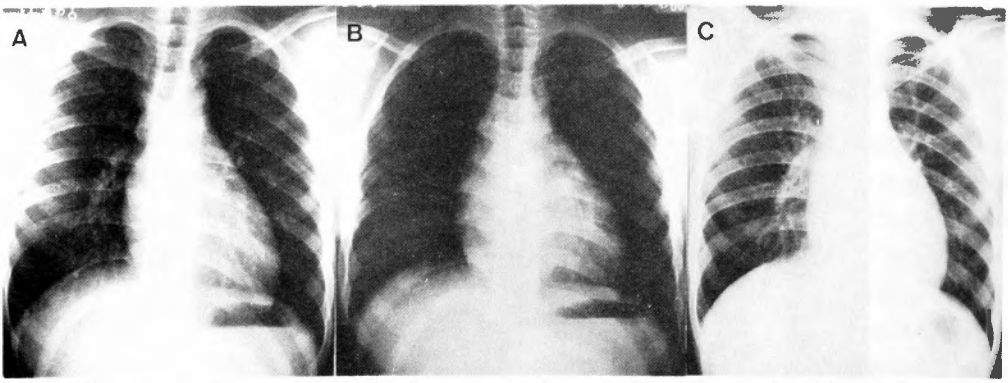

Fig. 3. A. Preoperative chest roentgenogram shows a mild cardiomegaly with a cardiothoracic ratio of 0.51. Pulmonary vascular markings are not increased. B, C. Postoperative chest roentgenograms taken on discharge (B) and 4 years after operation (C).

aortic root and the main pulmonary artery were 18 and 20 mm, respectively. Left femoral artery was prepared for the insertion of the catheter of intra-aortic baloon pumping (IABP). The left ventricle was extremely enlarged and hypertrophied, and its contractility was apparently unsatisfactory. The ascending aorta was enlarged as a result of poststenotic dilatation, where a strong systolic thrill was palpable. Prior to H-L bypass perfusion, IABP was started in order to increase the coronary blood flow. LV vent was inserted. The three cusps of the aortic valve were extremely hypertrophied. The aortic valvular orifice was 8 mm in diameter. If only aortic

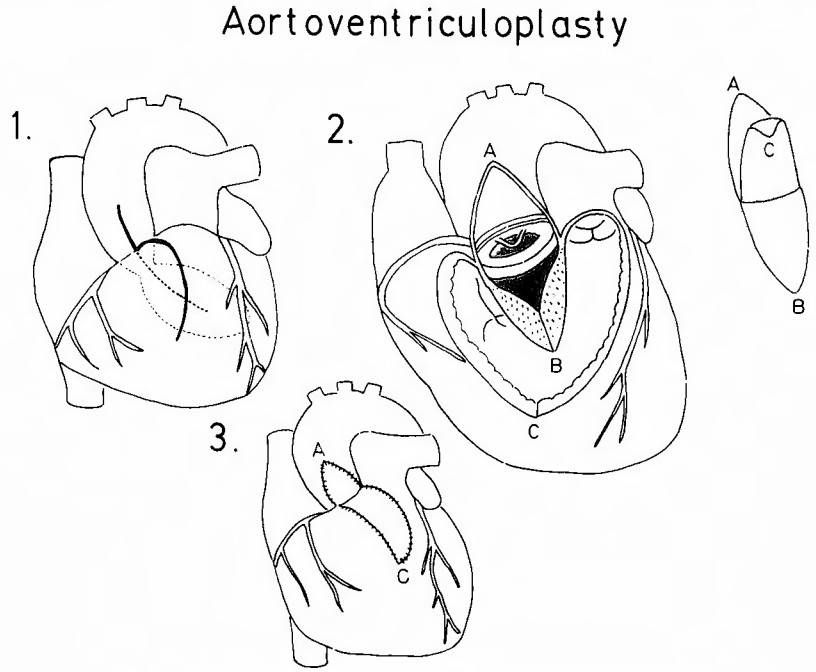

Fig. 4. Aortoventriculoplasty (KONNO's method)[4]

commissurotomy would have been performed, the pressure gradient may have been slightly decreased, but there would be a great possibility that subsequent aortic regurgitation may develop. Therefore we decided to perform aortic valve replacement. However, choosing the size of the prosthetic aortic valve is problematic; a size adequate for an adult should be inserted, to avoid the recurrence of aortic stenosis in the near future. The maximum size of aortic valve which can be inserted is 17 mm, however the minimum adult size is 21 mm in diameter. We decided to operate using KONNO's method (Fig. 4).

A longitudinal incision was made on the left anterior surface of the ascending aorta and extended down to the aortic annulus, with an adequate sewing margin remaining to the left of the right coronary ostium. Then the aortic annulus was transected at the commissure between the right coronary cusp and the left coronary cusp. The free wall of the right ventricular outflow tract was opened in the extension of the aortotomy. The incision was further extended downwards into the upper portion of the ventricular septum. The three cusps of the aortic valve were extremely hypertrophied, without the appearance of rheumatic disease. The cusps were resected satisfactorily near the annulus. The interventricular septum was extremely hypertrophied: 16 mm in width. The wall of the left ventricle was also greatly hypertrophied. The mitral valve was normal.

A Björk-Shiley prosthesis, No 21 AB, was sutured in the subcoronary portion. The inner surface of a woven Dacron graft (20 mm in diameter), which was preclotted, was lined with pericardium in order to minimize the oozing from the patch. And this graft was used to repair a defect in the aortic wall and the interventricular septum, and as a prosthesis for the remaining portion of aortic annulus. Then a triangular shaped graft, covered with pericardium, was sutured together to reconstruct the upper portion of the aortic annulus and in addition it was used to dilate the right ventriculotomy. During the operation, left coronary perfusion was done constantly, and right coronary perfusion was maintained as continuously as possible. After the intracardiac procedures were finished, contractility of the left ventricle was not good and occasional ventricular fibrillation occurred. IABP was started to increase the coronary blood flow during the diastolic phase, after which, systemic blood pressure increased and central venous blood pressure decreased. After the perfusion was stopped the LV-Ao. pressure gradient was 50 mmHg. IABP was continued after the operation. Bleeding from the posterior wall of the aorta was not difficult to control.

Congestive heart failure and low cardiac output syndrome continued two weeks postoperatively. Though Dopamine or Protanol were administered, they were not effective. As ST depression was extensive, IABP was further continued. The general condition gradually improved, and IABP was stopped after intermittent operating, on April 13. A severe diuretic regime was necessary due to pericardial and pleural effusion. The cardiac shadow on the chest roentgenogram decreased in size. Postoperative cardiac catheterization was performed on May 18, 1977 (Table I). The pressures (mmHg) were: main pulmonary artery 30/20 (mean 25), outflow tract of the right ventricle 45/15, inflow tract of the right ventricle 48/8, right atrium (8) and brachial artery 100/60 (80). Mild pulmonary stenosis was detected. As the catheter was not

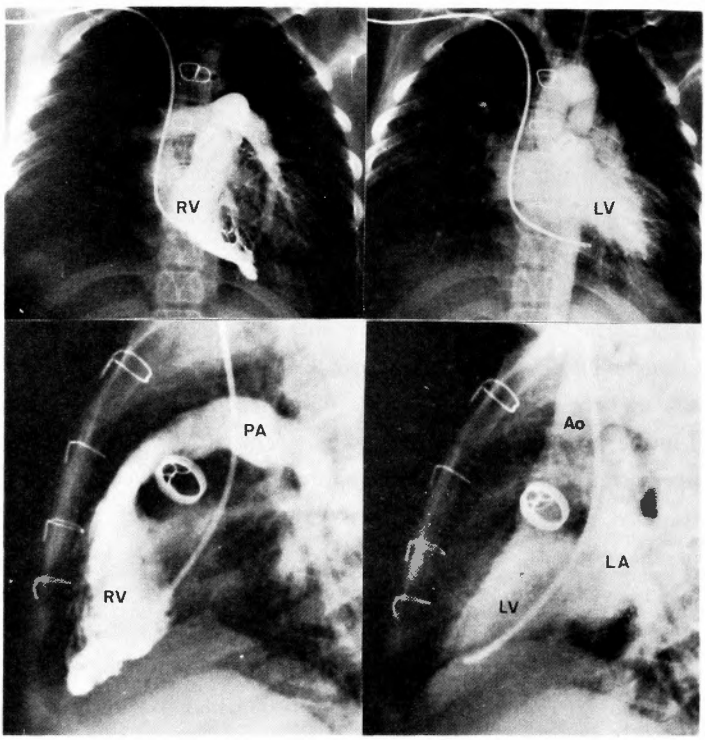

Fig. 5. The angiocardiogram in Case 1 taken one month postoperatively shows an adequately enlarged aortic root and a mild pulmonary stenosis.

passed through the aortic valve, LV-Ao. pressure gradient was not measured. Postoperative angiocardiography showed that the aortic annulus was adequately dilated (Fig. 5).

The patient was discharged on May 29, 1977, and he is active and doing well 4 years postoperatively.

Case 2.

The patient, a 12-year-old girl, was born after full-term pregnancy and normal delivery. Body weight at birth was 3170 gm.

A heart murmur was first detected at the age of 6 months when she had a common cold and was taken to a local doctor; she was advised to have an complete examination. She was originally diagnosed as having ventricular septal defect (VSD) in a hospital in Kyoto City. However the next year aortic stenosis, not VSD, was detected in the Department of Pediatrics in Kyoto University Hospital. On May 24, 1979, she underwent preoperative cardiac catheterization study. The pressure gradient across the aortic valve was 155 mmHg, mild pulmonary valvular stenosis was detected. Cardiac output was 3.08 L/min. and the cardiac index was 3.57 L/min./M^2 (BSA). No shunt was detected (Table I). The preoperative angiocardiography showed a mild aortic regurgitation and a moderate narrow aortic annulus (Fig. 7).

She was admitted to the 2nd Department of Surgery, Kyoto University Hospital, on September 25, 1979. Her height was 141 cm and body weight 39.5 Kg. Neither cyanosis nor

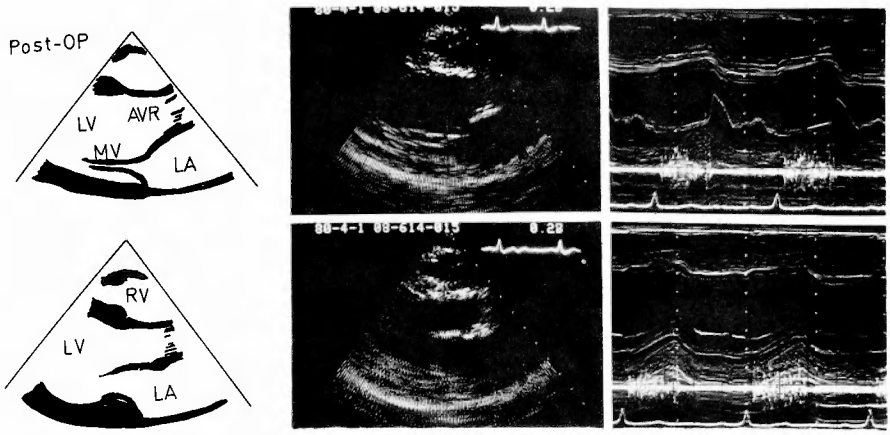

Fig. 6. The ultrasonic tomocardiogram in Case 1 taken 4 years postoperatively shows a decrease in width of interventricular septum and posterior left ventricular wall. But movement of the interventricular septum is paradoxical still now.

edema was present. Pulse was regular at a rate of 120 beats per minute. Blood pressure was 90/70 mmHg.

On auscultation, there was a Grade 5/6 blowing systolic murmur heard loudest in the 2nd

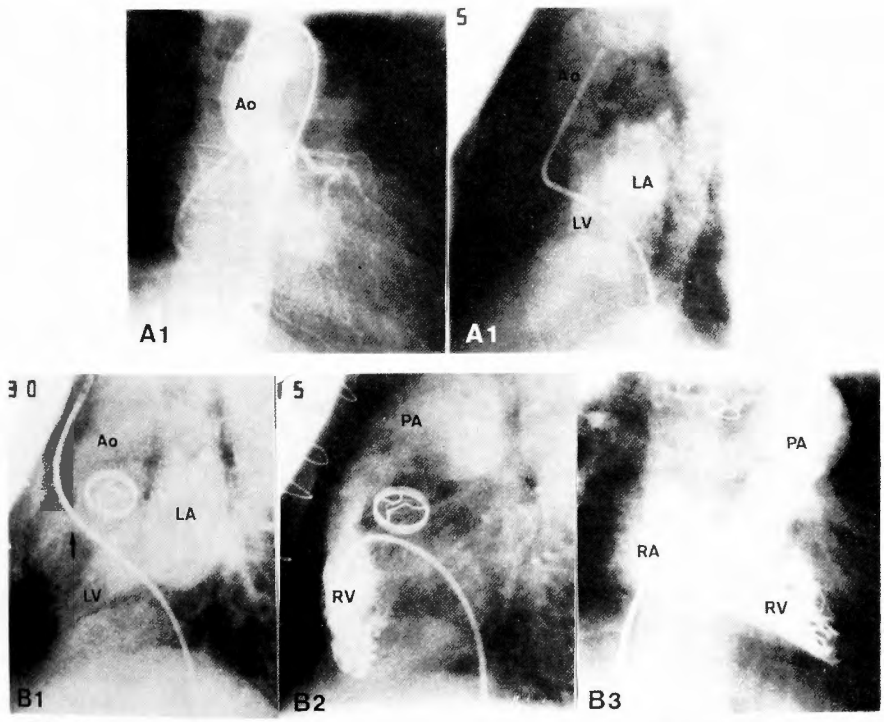

Fig. 7. A. Preoperative angiocardiogram, in which a valvular stenosis with a mild narrow aortic annulus and a mild regurgitation is shown. B. Postoperative angiocardiogram, in which an adequately enlarged aortic root, a left to right shunt (arrow in B1 points) and a moderate tricuspid regurgitation are shown.

intercostal space over the sternum, and a Grade 1/6 blowing diastolic murmur heard in the 3rd intercostal space. Thrill was strongly palpable in the suprasternal region. The electrocardiogram showed a regular sinus rhythm, with a mean electrical axis of 70 degrees, and left ventricular hypertrophy. S of V_1+R of V_5 was 7.7 mV and ST depression was found to be between 0.1 to 0.2 mV in $V_{5,6}$ (Fig. 8). Chest roentgenogram showed a mild cardiomegaly with a cardiothoracic rate of 0.54 (Fig. 9). Ultrasonic cardiogram revealed an increase in the width of the left ventricular wall and the interventricular septum, also there was midsystolic closure of the aortic cusp (Fig. 10).

An operation was performed on October 1, 1979. The severe coexisting concentric hypertrophy necessitated a safe means of myocardial protection to prevent development of stone heart. After the aorta was cross-clamped, 100 ml Young's solution and 500 ml of cardioplegic solution was infused into the aortic root. Then the heart was placed in an ice slush and its temperature was maintained below 15°C. The diameter of the aortic root was 10 mm. The three cusps of the aortic valve were extremely hypertrophied at the edges. The aortic stenosis was a result of subvalvular adhesion, and aortic ostium was 10 mm in diameter. As it appeared that valvotomy or prosthetic valve replacement could not alleviate the aortic stenosis, we decided to operate according to the KONNO's method (Fig. 4). The incision was extended to the commissure between the right and left coronary cusp and further to the outflow tract of the right ventricle and the interventricular septum. The interventricular septum was 15 mm in width, extremely

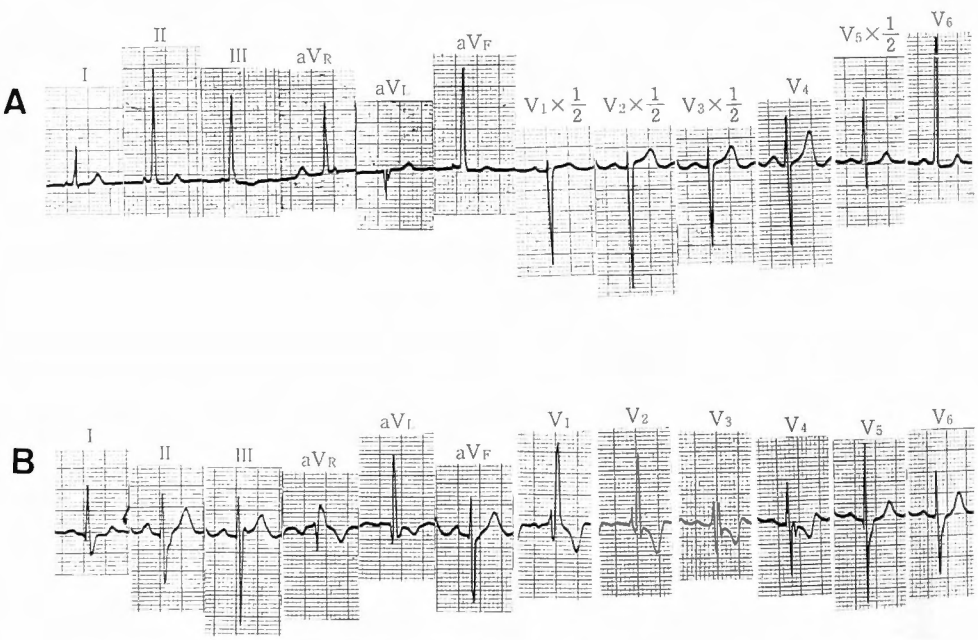

Fig. 8. A. Preoperative electrocardiogram in Case 2 shows a regular sinus rhythm, with a mean electrical axis of 70 degrees, and left ventricular hypertrophy. S of V1+R of V5 is 7.7 mV and ST depression is found to be between 0.1 to 0.2 mV in V5-6. B. Postoperative electrocardiogram shows a regular sinus rhythm associated with complete right bundle branch block.

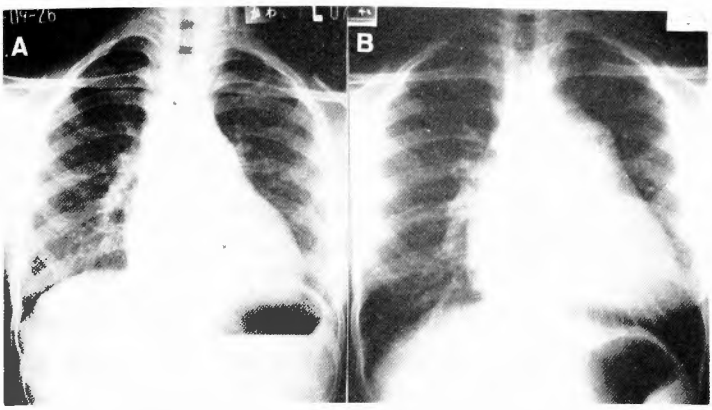

Fig. 9. A. Preoperative chest roentgenogram shows a cardiomegaly with a cardiothoracic rate of 0.54. B. The chest roentgenogram, taken one year postoperatively, shows a definite increaes in size of the cardiac shadow with a cardiothoracic ratio of 0.64 and increased pulmonary vascular markings.

hypertrophied and easy to be torn. The patch used for aortoventriculoplasy were fashioned out of knitted Dacron vascular grafts, 18 mm in diameter. Because of bleeding problems, the patches were covered with autologous pericardium. The same procedures as KONNO's method were performed. Easy weaning from heart-lung bypass perfusion was performed under operating IABP.

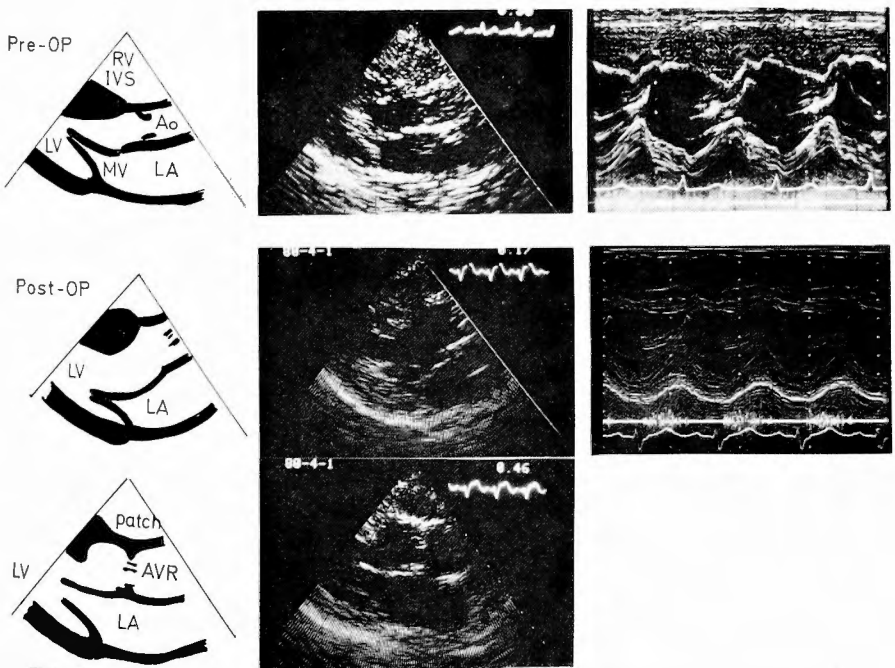

Fig. 10. Preoperative echocardiogram shows an extremely hypertrophied interventricular septum and posterior left ventricular wall. One year postoperative echocardiogram shows an enlarged right ventricular cavity.

The pressure gradient between the left ventricle and the aorta was 15 mmHg, measured immediately after operation. Bleeding around the patches was easy to stop by using Oxycel. A Björk-Shiley prosthesis, No 23 A, was inserted in the subcoronary position. Total time of anoxic clamp was 90 minutes, after which D-C shock was administered 3 times in order to restore sinus rhythm.

Congestive heart failure and low cardiac output syndrome continued. IABP was stopped on the second postoperative day, without any increase in central venous pressure or any decrease in systemic blood pressure.

Postoperative cardiac catheterization was performed on November 21, 1979. The pressures (mmHg) were as follows: left PA 40/20 (30), m-PA 40/20 (30), outflow of RV 60/2, 20, inflow of RV 60/2, 20. RA (17) and femoral artery 124/88 (101) (Table I). Angiocardiography revealed moderate tricuspid regurgitation and left to right shunt at the ventricular level (Fig. 7). Elevation of the end-diastolic pressure in the right ventricles was a result of tricuspid regurgitation. Left to right shunt was calculated to be 2.45 L/min. by Fick's method. Upon auscultation a Grade 5/6 harsh blowing systolic murmur was heard loudest in the left 4th intercostal space. Electrocardiogram showed a regular sinus rhythm associated with complete right bundle branch block and left ventricular hypertrophy (Fig. 8). On chest roentgenogram, pulmonary vascular markings were increased, with a cardiothoracic ratio of 0.64 (Fig. 9). Strict follow-up studies must be done to monitor left to right shunt and moderate tricuspid regurgitation. Reoperation may be necessary under certain circumstances.

Discussion

There are some techniques which are used to treat hypoplastic aortic annulus and to alleviate aortic stenosis, i.e. aortoventriculoplasty described by KONNO[4] and RASTAN[7] or a method[1)5)] in which the base of the noncoronary cusp is incised to insert a Dacron patch. An apical-aortic bypass, described by SARNOFF[8], was recently performed on a case in which hypoplastic aortic annulus was too extreme to insert a prosthetic valve. Among these techniques aortoventriculoplasty may be the most effective, having a widest indication and by which multi-level aortic stenosis can be managed optimally. However, interventricular septotomy and the prolonged use of aortic clamp may increase the frequency of complication such as low cardiac output syndrome, advanced myocardial failure, brain damage, transection of a dominant septal artery, severe acidosis with renal failure or hemolytic anemia. Our second case was complicated by left to right shunt and tricuspid regurgitation. The left to right shunt might be a result of incomplete suturing between the patch and the incised interventricular septum, which was easy to be torn. Tricuspid regurgitation might be a result of dysfunction of the papillary muscle due to the incision of the septum.

RASTAN[7] noted that aortoventriculoplasty has one limitation; that is in the very rare case of dominant septal and underdeveloped right coronary artery. One such patient with this type of coronary anomaly in his series died from right ventricular failure. Therefore, he recommended that the aortogram of patients must be studied carefully prior to aortoventriculoplasty to prevent

such a complication. In a small, growing child, only a very small aortic prosthetic valve can be inserted and such a valve will be stenotic either immediately or after a short period of time. In addition, anticoagulant therapy should be discontinued after the operation. JONES[3] and OHHIRA[6] used a porcine xenograft valve as a substitute for a prosthetic valve. However, this application may not always be advisable from the standpoint of tolerance of the replaced valve, especially in children. We favor the use of a Björk-Shiley prosthesis. Because the ratio of the ostium of this valve to its valvular ring is larger than that of any other valve. But it should be noted that the safety of such a complex surgery greatly depends upon recent improvements in cardioplegia. RASTAN also used a cardioplegic solution during an aortoventriculoplasy operation and he obtained a low mortality rate of 24%. For myocardial protection, we used intermittent coronary perfusion in Case 1, and cardioplegia in Case 2. In addition we introduced IABP as a safer means of myocardial protection to prevent development of stone heart.[2]

Summary

KONNO's operation was performed on 2 cases with severe aortic valvular stenosis due to narrow annulus. In the first case, a 13-year-old boy, a Björk-Shiley prosthesis of 21 mm in diameter was sutured on the annulus. In the early postoperative period low cardiac output syndrome appeared but was effectively controlled by medication and IABP. The boy is now active and doing well. Postoperative cardiac catheterization and angiography revealed excellent results. In the second case, a 12-year-old girl, a Björk-Shiley prosthesis of 23 mm in diameter was sutured on the annulus. Moderate right cardiac failure continued 2 weeks postoperatively, and was gradually controlled by a severe regime of diuretic and digitalis. IABP was operating 2 days postoperatively. In addition she had a moderate left to right shunt and moderate tricuspid regurgitation. Her physical movements are restricted.

This surgical method is useful in cases of aortic stenosis at any level, especially in valvular stenosis associated narrow annulus.

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和文抄録

狭小弁輪を伴う大動脈狭窄症の外科治療

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弁輪狭小を伴う大動脈狭窄症2例に対し，今野の手術を施行した．第1例は13才男児で，Björk-Shiley 弁(21 mm) を使用した．術後，低心拍出症候群を来たしたが，IABP を使用し有効であった．現在元気で通学している．第2例は12才女児で，Björk-Shiley 弁 (23 mm) を使用した．術後，左→右短絡と三尖弁閉鎖不全を残し右心不全を来たした．本例にも，開心術直前および術後 IABP を使用し，有効であった．

今野の手術は，広く種々の型の大動脈狭窄症に適応され得るが，その侵襲は大きく心筋保護を充分に行う必要がある．